Microimaging Hardware Installation

UNITYINOVA NMR Spectrometer Systems

Pub. No. 01-999070-00, Rev. A0499

VARIAN

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Microimaging module installed on
UNITY*INOVA* NMR spectrometer systems

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Table of Contents

List of Figures

List of Tables

SAFETY PRECAUTIONS

The following warning and caution notices illustrate the style used in Varian manuals for safety precaution notices and explain when each type is used:

WARNING: ***Warnings*** **are used when failure to observe instructions or precautions could result in injury or death to humans or animals, or significant property damage.**

CAUTION: ***Cautions*** **are used when failure to observe instructions could result in serious damage to equipment or loss of data.**

Warning Notices

Observe the following precautions during installation, operation, maintenance, and repair of the instrument. Failure to comply with these warnings, or with specific warnings elsewhere in Varian manuals, violates safety standards of design, manufacture, and intended use of the instrument. Varian assumes no liability for customer failure to comply with these precautions.

WARNING: **Persons with implanted or attached medical devices such as pacemakers and prosthetic parts must remain outside the 5-gauss perimeter from the centerline of the magnet.**

The superconducting magnet system generates strong magnetic fields that can affect operation of some cardiac pacemakers or harm implanted or attached devices such as prosthetic parts and metal blood vessel clips and clamps.

Pacemaker wearers should consult the user manual provided by the pacemaker manufacturer or contact the pacemaker manufacturer to determine the effect on a specific pacemaker. Pacemaker wearers should also always notify their physician and discuss the health risks of being in proximity to magnetic fields. Wearers of metal prosthetics and implants should contact their physician to determine if a danger exists.

Refer to the manuals supplied with the magnet for the size of a typical 5-gauss stray field. This gauss level should be checked after the magnet is installed.

WARNING: **Keep metal objects outside the 10-gauss perimeter from the centerline of the magnet.**

The strong magnetic field surrounding the magnet attracts objects containing steel, iron, or other ferromagnetic materials, which includes most ordinary tools, electronic equipment, compressed gas cylinders, steel chairs, and steel carts. Unless restrained, such objects can suddenly fly towards the magnet, causing possible personal injury and extensive damage to the probe, dewar, and superconducting solenoid. The greater the mass of the object, the more the magnet attracts the object.

Only nonferromagnetic materials—plastics, aluminum, wood, nonmagnetic stainless steel, etc.—should be used in the area around the magnet. If an object is stuck to the magnet surface and cannot easily be removed by hand, contact Varian service for assistance.

Warning Notices (*continued*)

Refer to the manuals supplied with the magnet for the size of a typical 10-gauss stray field. This gauss level should be checked after the magnet is installed.

WARNING: **Only qualified maintenance personnel shall remove equipment covers or make internal adjustments.**

Dangerous high voltages that can kill or injure exist inside the instrument. Before working inside a cabinet, turn off the main system power switch located on the back of the console.

WARNING: **Do not substitute parts or modify the instrument.**

Any unauthorized modification could injure personnel or damage equipment and potentially terminate the warranty agreements and/or service contract. Written authorization approved by a Varian, Inc. product manager is required to implement any changes to the hardware of a Varian NMR spectrometer. Maintain safety features by referring system service to a Varian service office.

WARNING: **Do not operate in the presence of flammable gases or fumes.**

Operation with flammable gases or fumes present creates the risk of injury or death from toxic fumes, explosion, or fire.

WARNING: **Leave area immediately in the event of a magnet quench.**

If the magnet dewar should quench (sudden appearance of gasses from the top of the dewar), leave the area immediately. Sudden release of helium or nitrogen gases can rapidly displace oxygen in an enclosed space creating a possibility of asphyxiation. Do not return until the oxygen level returns to normal.

WARNING: **Avoid helium or nitrogen contact with any part of the body.**

In contact with the body, helium and nitrogen can cause an injury similar to a burn. Never place your head over the helium and nitrogen exit tubes on top of the magnet. If helium or nitrogen contacts the body, seek immediate medical attention, especially if the skin is blistered or the eyes are affected.

WARNING: **Do not look down the upper barrel.**

Unless the probe is removed from the magnet, never look down the upper barrel. You could be injured by the sample tube as it ejects pneumatically from the probe.

WARNING: **Do not exceed the boiling or freezing point of a sample during variable temperature experiments.**

A sample tube subjected to a change in temperature can build up excessive pressure, which can break the sample tube glass and cause injury by flying glass and toxic materials. To avoid this hazard, establish the freezing and boiling point of a sample before doing a variable temperature experiment.

Warning Notices (*continued*)

WARNING: **Support the magnet and prevent it from tipping over.**

The magnet dewar has a high center of gravity and could tip over in an earthquake or after being struck by a large object, injuring personnel and causing sudden, dangerous release of nitrogen and helium gasses from the dewar. Therefore, the magnet must be supported by at least one of two methods: with ropes suspended from the ceiling or with the antivibration legs bolted to the floor. Refer to the *Installation Planning Manual* for details.

WARNING: **Do not remove the relief valves on the vent tubes.**

The relief valves prevent air from entering the nitrogen and helium vent tubes. Air that enters the magnet contains moisture that can freeze, causing blockage of the vent tubes and possibly extensive damage to the magnet. It could also cause a sudden dangerous release of nitrogen and helium gases from the dewar. Except when transferring nitrogen or helium, be certain that the relief valves are secured on the vent tubes.

WARNING: **On magnets with removable quench tubes, keep the tubes in place except during helium servicing.**

On Varian 200- and 300-MHz 54-mm magnets only, the dewar includes removable helium vent tubes. If the magnet dewar should quench (sudden appearance of gases from the top of the dewar) and the vent tubes are not in place, the helium gas would be partially vented sideways, possibly injuring the skin and eyes of personnel beside the magnet. During helium servicing, when the tubes must be removed, follow carefully the instructions and safety precautions given in the manual supplied with the magnet.

Caution Notices

Observe the following precautions during installation, operation, maintenance, and repair of the instrument. Failure to comply with these cautions, or with specific cautions elsewhere in Varian manuals, violates safety standards of design, manufacture, and intended use of the instrument. Varian assumes no liability for customer failure to comply with these precautions.

CAUTION: **Keep magnetic media, ATM and credit cards, and watches outside the 5-gauss perimeter from the centerline of the magnet.**

The strong magnetic field surrounding a superconducting magnet can erase magnetic media such as floppy disks and tapes. The field can also damage the strip of magnetic media found on credit cards, automatic teller machine (ATM) cards, and similar plastic cards. Many wrist and pocket watches are also susceptible to damage from intense magnetism.

Refer to the manuals supplied with the magnet for the size of a typical 5-gauss stray field. This gauss level should be checked after the magnet is installed.

Caution Notices (*continued*)

CAUTION: **Check helium and nitrogen gas flowmeters daily.**

Record the readings to establish the operating level. The readings will vary somewhat because of changes in barometric pressure from weather fronts. If the readings for either gas should change abruptly, contact qualified maintenance personnel. Failure to correct the cause of abnormal readings could result in extensive equipment damage.

CAUTION: **Never operate solids high-power amplifiers with liquids probes.**

On systems with solids high-power amplifiers, never operate the amplifiers with a liquids probe. The high power available from these amplifiers will destroy liquids probes. Use the appropriate high-power probe with the high-power amplifier.

CAUTION: **Take electrostatic discharge (ESD) precautions to avoid damage to sensitive electronic components.**

Wear grounded antistatic wristband or equivalent before touching any parts inside the doors and covers of the spectrometer system. Also, take ESD precautions when working near the exposed cable connectors on the back of the console.

Radio-Frequency Emission Regulations

The covers on the instrument form a barrier to radio-frequency (rf) energy. Removing any of the covers or modifying the instrument may lead to increased susceptibility to rf interference within the instrument and may increase the rf energy transmitted by the instrument in violation of regulations covering rf emissions. It is the operator’s responsibility to maintain the instrument in a condition that does not violate rf emission requirements.

UNITY*INOVA* Microimaging Module

The UNITY*INOVA* microimaging module consists of a one-phase continuous-frequency synthesizer, one rf waveform generator, three gradient waveform generators, three gradient amplifiers, a linear rf preamplifier, and the basic microimaging module. The basic module is not frequency specific. The basic module provides for rf and gradient waveform generation, gradient signal conditioning, gradient current drive amplification, a safety interlock system. All microimaging pulse sequence timing remains under master control of the pulse controller board.

The microimaging cabinet (see Figure 1) for the microimaging module houses the safety interlock board, three gradient amplifiers, a power distribution unit, and a gradient system status panel.

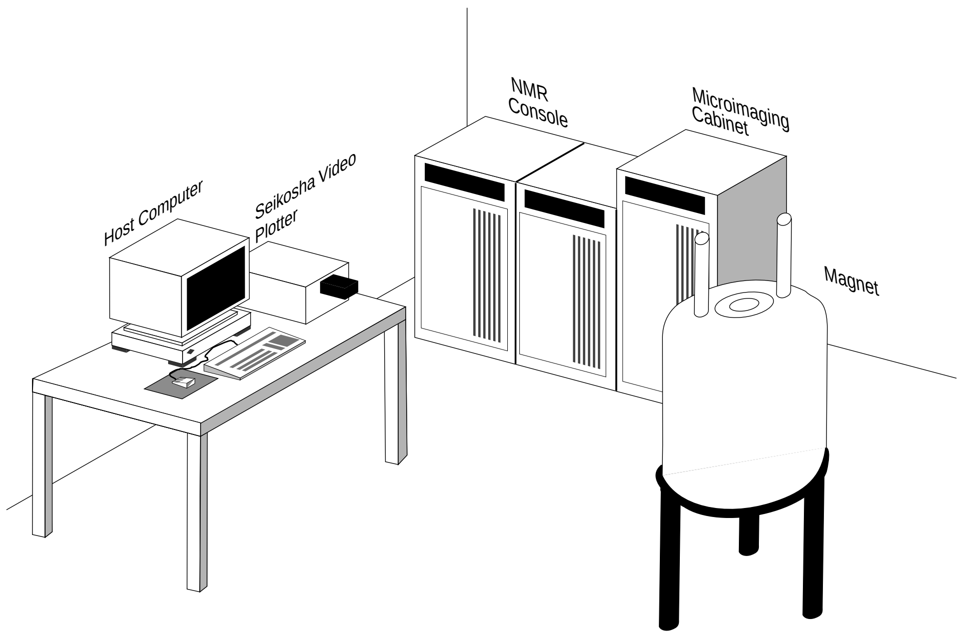

Figure 1. Microimaging System Layout

The Varian microimaging module can be can be installed on Varian UNITY*INOVA* 300- or 400-MHz, 89-mm vertical bore NMR spectrometer. This module adds the X, Y, and Z gradient capabilities for microimaging experiments. Many of the hardware and software operations and utilities of the liquids spectrometer, particularly those involved with 2D NMR, remain the same.

Field mapping of all magnets is recommended for good homogeneity over large volumes (microimaging samples greater than 5 mm), especially for systems with 23 or more RT shims coils. Field mapping is sold separately.

Instructions for installing the microimaging module on UNITY*INOVA* NMR spectrometers is described in this manual. The major installation steps are covered in the following sections:

- Preparing for Installation, page 10
- Installing Microimaging Hardware, page 12

- Configuring VNMR for Microimaging, page 21
- Testing and Verifying the Gradient System, page 22
- Calibrating and Configuring Gradient Strength, page 23

The last section in this manual, System Protection and Status, page 27, describes the microimaging hardware.

Preparing for Installation

Installing and testing the microimaging module requires the equipment listed below:

- Dual-trace oscilloscope capable of accurate peak-to-peak voltage (Vpp) and measurements between 9 and 200 MHz (Factory installations also require a digital oscilloscope with memory.)
- 500-W, 30-dB attenuator
- Spectrum analyzer
- Varian field service engineer tool kit

Complete the following steps before installing the microimaging module:

1. The microimaging cabinet (see Figure 2) requires a three-phase, high-current power source. Verify that the main supply is 208 V/60 A, 240 V/50 A, 380 V/40 A, or 415 V/30A and is separate from the 20 A power line to the UNITY*INOVA* console.

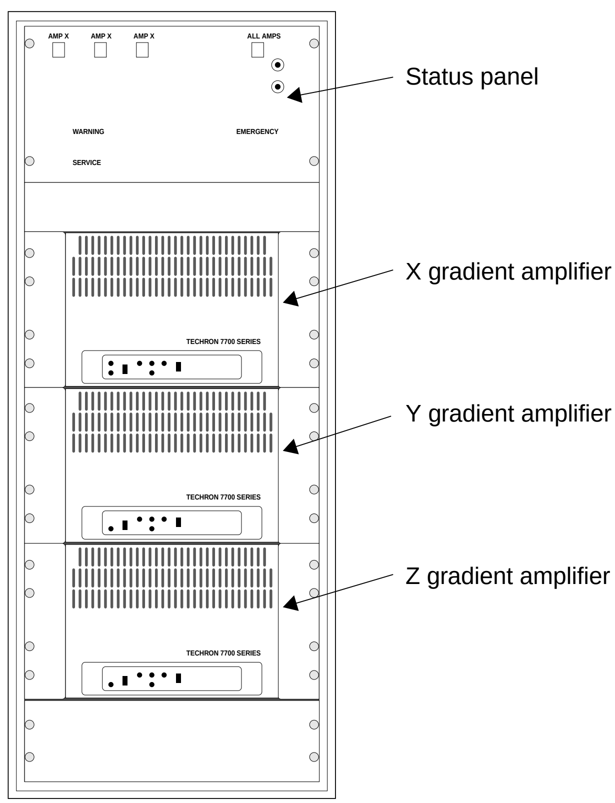

Figure 2. Microimaging Cabinet with Gradient Control System, Open Front View

2. Check the items in the shipping kit against the parts list provided in the kit. If all the parts on the list are included in the kit, proceed to the next step. If anything is missing, obtain it before proceeding.

WARNING: **Equipment and tools used by the moving crew must be evaluated for safety in the magnetic field. Install a plastic chain (or chain of other nonmagnetlc material) at about 42 in. (107 cm) from the magnet body. This serves as a reminder to prevent magnetic materials (consoles for example) from being pulled Into the magnet body.**

CAUTION: **Keep metal objects away from the magnet. The strong magnetic field of the dewar attracts ferromagnetic objects, such as compressed gas cylinders, steel chairs, steel carts, and the microimaging cabinet. Unless restrained, such objects can strike the magnet, causing extensive damage to the probe, the dewar, and the superconducting solenoid. Use only nonferromagnetic materials (such as plastics, aluminum, wood, and stainless steel) in the area around the magnet.**

3. Verify that there is enough room to accommodate the microimaging cabinet in the floor plan of the laboratory (see the *Installation Planning Guide*). The following are space guidelines:

   a. Measure the distance between the edge of the UNITY*INOVA* cabinet and the centerline of the magnet.

   b. If this distance is greater than 185 cm (73 in), and only the microimaging cabinet is going to be installed, then go on to step 6. If the distance is less than 185 cm (73 in), determine how much distance must be added to accommodate the microimaging cabinet:

________	–	________	=	________________
185 cm (73 in)		measured distance		additional distance needed

   c. Place the UNITY*INOVA* cabinet at the correct distance (the left edge of the cabinet must be at least 48 inches away from the center of the magnet). Disconnect all cables from the magnet leg and move them away from the right side of the console.

WARNING: **Only qualified maintenance personnel shall remove equipment covers or make internal adjustments.**

Dangerous high voltages that can kill or injure exist inside the instrument. Before working inside a cabinet, turn off the main system power switch located on the back of the console.

4. Shut down the system.

5. Remove the power connector from the rear of the UNITY*INOVA* cabinet.

CAUTION: **The following installation involves handling static-sensitive equipment and printed circuit boards. Take all precautions necessary to suppress electrostatic spikes and discharges near the devices: stand on antistatic pads, wear natural fiber materials, and use a grounded antistatic wristband before touching any equipment, etc. Be especially careful with red-colored boards. These are extremely static**

sensitive. Failure to suppress electrostatic discharges can result In permanent damage to components.

Installing Microimaging Hardware

The procedures in this section describe how to install the various parts of the microimaging hardware. Be sure that you have completed Preparing for Installation, page 10, before continuing with the installation. This section contains the following procedures:

Installing the Imaging Switch Board

There are two imaging switch boards:

- For systems with the Oxford ribbon cable style of room temperature shims, the board to install in the shim supply is Part No. 01-903922-xx.
- For systems with the Oxford red tube room temperature shims, the board to install in the shim supply is Part No. 00-993958-xx.

The installation procedure for each board is quite similar.

To verify whether the imaging switch board is installed, look at the back of the shim power supply. If there are three triax connectors (X, Y, and Z1), the board is installed and you can skip to Installing the PTS Synthesizer with Overrange, page 14.

The Imaging Switch board disconnects the X, Y, and Z1 room temperature shim coils from the output of the Varian shim supply, and connects the Varian outputs to the digital eddy current compensation (DECC) connector boards (X, Y, and Z) whenever the corresponding Techron gradient amplifier is enabled. This enables X, Y, and Z1 shimming through the gradient coil set.

Imaging Switch Board, Part No. 01-993958-xx

1. Disconnect the power from the shim power supply and disconnect the shim coil cable.
2. Carefully remove the shim power supply from the console.
3. Remove the cover from the shim power supply.

In the rear of the supply are two D shell connectors J908 and J909 that are mounted to a removable plate.

4. Remove the two screws fastening the plate to the rear wall of the shim supply, and remove the plate. Remove the two connectors from this plate.
5. Connect the 37-pin D shell connector into J1 of the Imaging Switch board.
6. Tiewrap the unused 9-pin D shell connector so it won't rattle around.
7. Mount the Imaging Switch board, which has its own metal bracket, inside the supply in the spot vacated by the removable plate.
8. Replace the shim supply cover and replace the shim supply back into the console.
9. Reattach the shim coil cable to J908 of the Imaging Switch's metal bracket.
10. Go to Connecting the Imaging Switch Board, this page to connect the cables.

Imaging Switch Board, Part No. 01-903922-xx

1. Disconnect the power from the shim power supply and disconnect the shim coil cable.
2. Carefully remove the shim power supply from the console.
3. Remove the cover from the shim power supply.

   In the rear of the supply are two D shell connectors J908 and J909 that are mounted to a removable plate.
4. Remove the two screws fastening the plate to the rear wall of the shim supply, and remove the plate. Remove the 64-position pin ribbon cable connector from this plate.
5. Connect the 64-pin ribbon cable connector into P907 of the Imaging Switch board.
6. Mount the Imaging Switch board, which has its own metal bracket, inside the supply in the spot vacated by the removable plate.
7. Replace the shim supply cover and replace the shim supply back into the console.
8. Reattach the shim coil cable to J907 of the Imaging Switch's metal bracket.
9. Go to Connecting the Imaging Switch Board, this page to connect the cables.

Connecting the Imaging Switch Board

1. For Part No. 01-993958-XX, connect the Oxford room temperature shim coils to J908 of the Imaging Switch board. J908 is located on the rear of the Varian shim supply.

   For Part No. 01-903922-XX, connect the Oxford room temperature shim coils to J907 of the Imaging Switch board. J907 is located on the rear of the Varian shim supply.
2. Connect the cable from J6 of the Safety Interlock board to J2 of the Imaging Switch board. J2 is located on the rear of the Varian shim supply.
3. Connect the three blue twinax cables from the DECC connector boards, to the X, Y, and Z1 connectors of the Imaging Switch board. The twinax connectors are located on the rear of the Varian shim supply.
4. Make sure the power cable is connected.

Installing the PTS Synthesizer with Overrange

This procedure describes how to install the PTS-500 frequency synthesizer with overrange, Part No. 00-990880-01.

1. Remove power, disconnect all cables, and remove the connector board from the rear of the PTS unit in the UNITY*INOVA* NMR console. Remove the PTS from the cabinet.
2. Install the new PTS-500 unit in the vacant space. Adjust the 10 MHz OUT of the PTS-500 to between 8 and l0 dB of signal.
3. Connect the PTS Connector board (00-992106-00) to the PTS-500. Also, install the overrange cable (00-993015-00) between the PTS-500 and PTS Connector board.
4. Check the dip switch settings for overrange.
5. Reconnect the coaxial cables to the PTS-500.

Installing the Connector, DECC, and SDAC Boards

The Connector board is installed into the back of the rf control card cage and the DECC and SDAC boards are installed into the connector board.

1. Remove the old DAC and GCU boards, and the waveform generator cable, if present.
2. Choose two adjacent slots in which to install the DECC and SDAC.

   Figure 3 shows the layout of the rf control card cage. Ideally, the DECC and the SDAC boards are installed next to the lock transceiver controller boards, shown as A through F in Figure 3 (note that on imaging systems, if there is no DIFF AMP board installed, the Lock Transceiver Controller board is not needed and slot 7 becomes a spare slot).

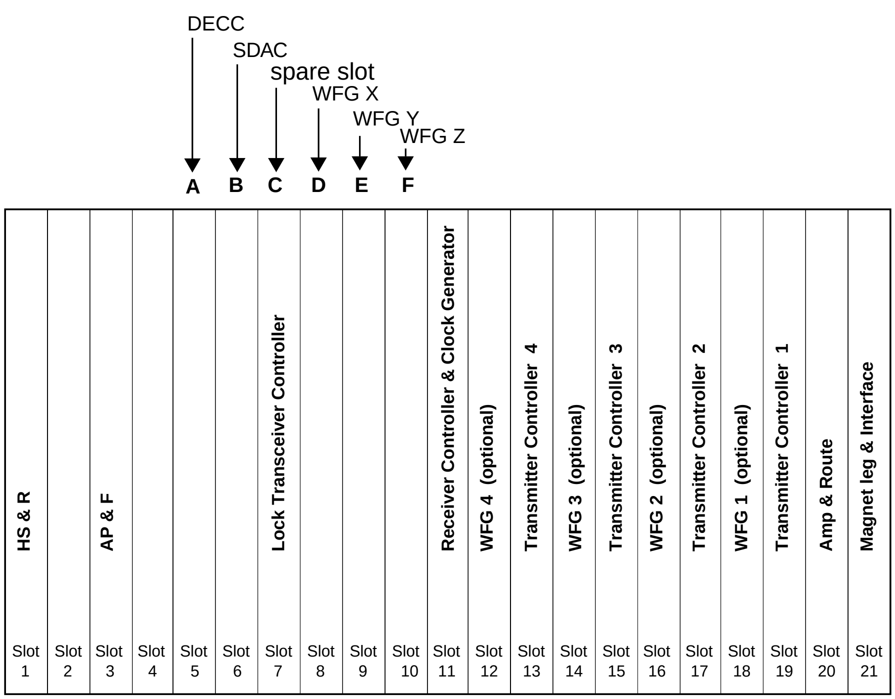

Figure 3. RF Control Cardcage, Front View, Showing Slot Assignments

3. Install the Connector board (01-904736-00) into the back of the two slots selected for the DECC and SDAC. Line up the Connector board in the back of the card cage, above two open P2 connectors. Use the M2.5X8 screws provided (12-168209-00).

   The Connector board provides power to the DECC and SDAC boards, and serves as the P1 connector (upper) in the card cage.

4. On the SDAC board, set the J8 jumper to select current or voltage mode:
   - Jumper J8 out – B0 driver is in current mode, providing up to about 500 mA.
   - Jumper J8 in – B0 driver is in voltage mode, providing a voltage signal to an external current amplifier.

   The B0 driver circuit on the SDAC can provide up to about 500 mA of current. For coils where this would not be enough drive, an external amplifier is needed. For an external amplifier, the B0 circuit provides a voltage signal to the external current amplifier.

5. Install the DECC and SDAC boards into the slots where the connector board has been installed. The DECC board is on the left.

Installing the Gradient Waveform Generator Boards

The Gradient Waveform Generator boards are installed in the rf control card cage.

1. Locate the Gradient Waveform Generator boards (01-902034-xx). Verify that their jumpers and switches are correct for their respective gradients. See Table 1.

Table 1. Gradient Waveform Generator Board Jumper Settings

Jumper	*Gradient Channel X*	*Gradient Channel Y*	*Gradient Channel Z*	*Gradient Channel W*
J2	1-2	1-2	1-2	1-2
J8	1-2	1-2	1-2	1-2
J9	1-2	1-2	1-2	1-2
J10	1-2	1-2	1-2	1-2
J17	1-2	1-2	1-2	1-2
J16	Not Used for Gradients	Not Used for Gradients	Not Used for Gradients	Not Used for Gradients
Switch	*2 Gradients*	*3 Gradients*	*4 Gradients*	*5 Gradients*
SW-1	2	3	4	5

2. Insert the Gradient Waveform Generator boards into the nearest three spare slots to the right of the Smart DAC board, with X being the closest to the Gradient DAC board.

3. Using the SMB cables that were used in the microimaging cabinet to provide 40 MHz to the Waveform Generator boards, connect a 40-MHz clock from the Receiver Controller to each of the Waveform Generator boards. Use an SMB T (58-180018-00) if not enough outputs are available. See Figure 4.

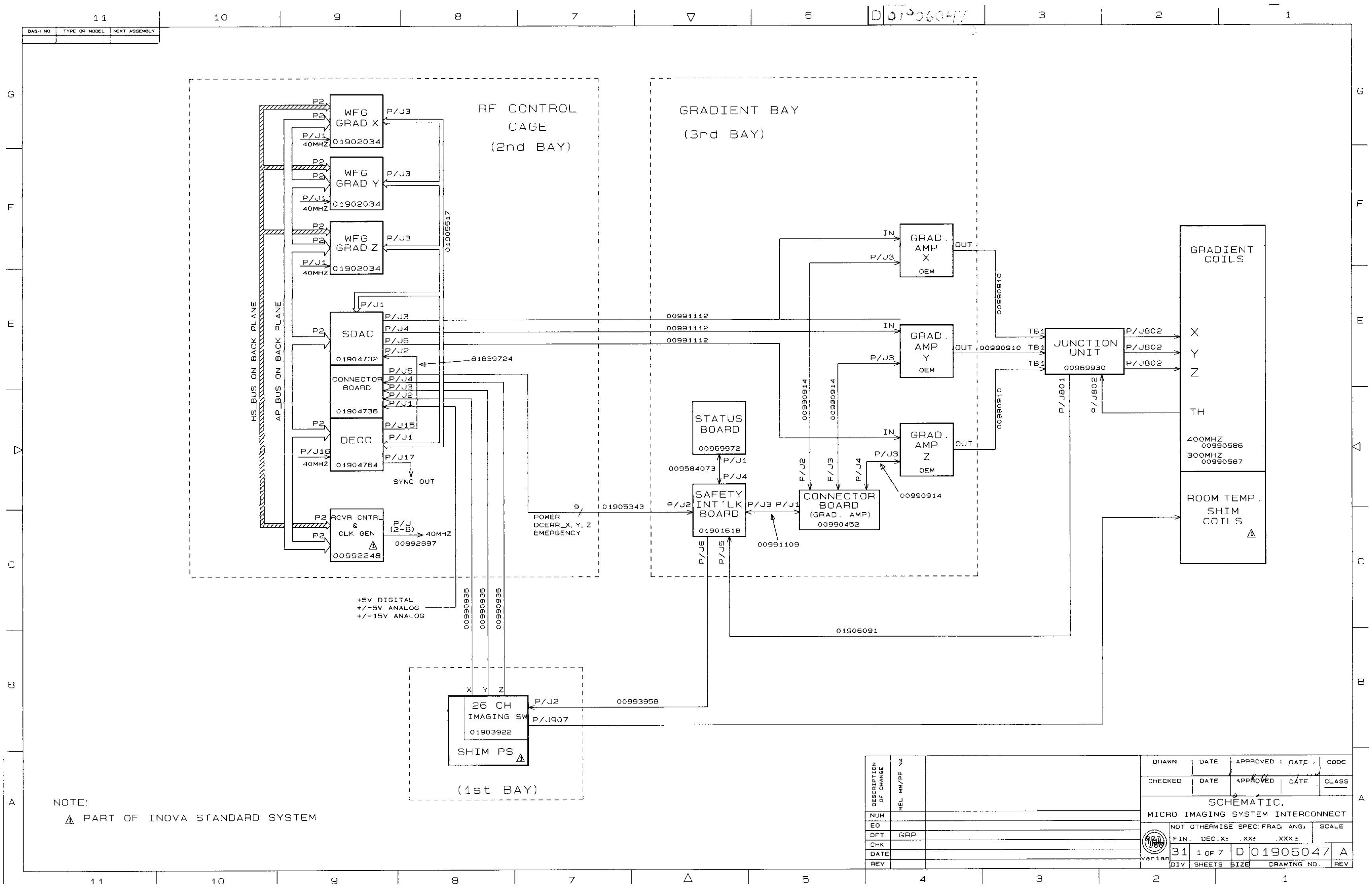

Figure 4. UNITYINOVA Microimaging Interconnect

Installing the Voltage Regulator Module

1. Remove the blank panel from the back of the rf cabinet, if necessary.
2. Mount the voltage regulator module (01-905652-00) in the back of the rf cabinet, as shown in Figure 5. Use the #10 screws, nuts, and washers (12-222060-08, 14-122010-00, and 14-202010-00).

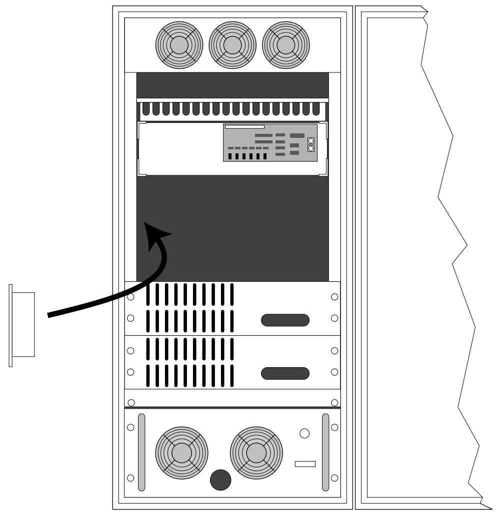

Figure 5. Voltage Regulator Module Installation

3. Connect the following leads:
   - +15, to TB1001-7
   - GND, to TB1001-8
   - –15, to TB1001-9
4. Connect the pigtail cable (with the 16-pin white Molex connector) from the voltage regulator module to the back of the Connector board.

Connecting the Cables

The power and the gradient amplifier must still be off before connecting the cables, as described in the steps below.

1. Connect the mini DIN-8 patch cable (81-839724-00) between the DECC and the SDAC boards.
2. Connect the ribbon cable (01-905517-00) to the gradient waveform generators, to the SDAC, and to the DECC.
3. Connect J16 on the DECC board to 40 MHz, using the SMB Cable (00-992897-04). Use the SMB T-adapter (58-180018-00) if necessary.
4. Connect the twinax cables between the SDAC and the gradient amplifiers.
5. Connect the B0 output from the SDAC to the coil or external amplifier, as appropriate.

6. For systems in which the X, Y, and Z shim fields (i.e., X1, Y1 and Z1) are created from the gradient coils, install the shim adapter cable (01-905516-00). The appropriate shim power supply—in which the X, Y and Z shim signals are voltage signals, as opposed to current signals—must be used.
   - Connect the male end of the 37-pin D-shell connector to the shim power supply.
   - Connect the twinax "breakout" cables to the back of the Connector board.
   - Connect the female end of the 37-pin D-shell connector to the shims (higher order).

Finishing the Hardware Installation

Finish the hardware installation by turning on system power as described in the steps below.

1. Turn on system power in the following order:
   - Console main power
   - RF and digital power on the front of the console
2. Switch on the gradient amplifiers and the shim power supply.

The hardware installation is complete. To test the DECC accessory, go to the next section.

Testing the DECC Accessory

Test the DECC accessory using the steps in this section.

1. Disconnect the ribbon cable (01-905517-00) from the DECC board.
2. Connect a jumper between pins 68 and 66 on the 68-pin condo connector on the DECC board, as shown in Figure 6.

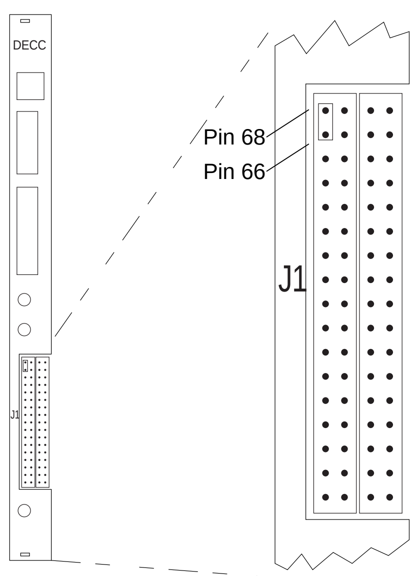

Figure 6. Self-Test Jumper on DECC Board

3. Press the **Reset** button on the front of the DECC board. This starts the self test.

   A 10-Hz sine wave will be present at the DECC board outputs. Measure the sine wave at the test points in the front of the board with an oscilloscope.

The LEDs also provide a visual indication of the 10 Hz wave. When the jumper is removed, or if the board is reset without the jumper present, the board goes into normal mode, waiting for the start of an experiment. In this mode, there should be a total of 6 LEDs on at the front of the DECC board.

When the power is on, the 6 green power indicator LEDs on the front of the SDAC should be lit.

4. After the test, return the system to normal mode:
   - Remove the self-test jumper that you connected in step 2 above. See Figure 6.
   - Attach the ribbon cable to the DECC.

Connecting the Power

The following procedures describe how to connect the power and signal cables to the microimaging cabinet. The microimaging cabinet is powered by a 3-phase source separate from the power source for the rest of the UNITY*INOVA* system. The Power Distribution Unit (PDU) is located at the bottom-rear of the cabinet. The PDU has a 15 foot cable that must be appropriately terminated in a 3-phase type connector to match the 3-phase power outlet provided by the user. Table 2 lists the connectors and plug destinations.

Table 2. Microimaging Cabinet Power Connections

Connectors	*Plug Destinations*
green: ground	G
white: neutral	W
black: hot	X
orange: hot	Y
red: hot	Z

Make sure the circuit breaker switch on the PDU is off before the power source at the wall is connected and turned on.

CAUTION: **Make sure the voltage/current ratings of the PDU match the ratings of the source. A mismatch can cause electrical failure.**

1. Check in the microimaging cabinet that each gradient amplifier is connected to the three-phase connectors of the PDU.
2. Check to see that the card cage voltage selector (at the rear power input module of the card cage) is set to the proper single-phase voltage corresponding to the voltage rating on the PDU. Check that the card cage is connected with the power cord to the PDU.

Installing the Junction Unit and Gradient Harness

1. Place the junction unit (00-969930-00) near the magnet.

WARNING: **Make sure the ac power to the microimaging cabinet is OFF. Disconnect the power cord from the microimaging cabinet. Although safety circuits exist to protect the user if the junction unit is opened, it is highly advisable to work with the ac power off since the gradient amplifiers can put out lethal amounts of power.**

CAUTION: Do not connect the harness leads to COMMON. This can cause excessive currents to flow through the gradient coil, which might damage the coil if the in-line fuses do not protect it properly.

2. Connect the heavy gauge gradient current harness (00-990910-00) to TB1 of the junction unit. Connect the other end of the gradient current harness to each of the gradient amplifiers. For each amplifier, the two harness leads should be connected to OUTPUT and SAMPLED COMMON.

   A 2.7-ohm resistor must go between SAMPLED COMMON and the amplifier chassis—make sure the chassis end is making good electrical contact. The chassis must also make good contact to the side of the gradient current harness.

3. Connect the 37-pin D shell cable (00-990914-20) from J741 on the rear of the microimaging cabinet to J801 of the junction unit.

4. Check that the air hoses are properly connected. See the air flow diagram in Figure 7.

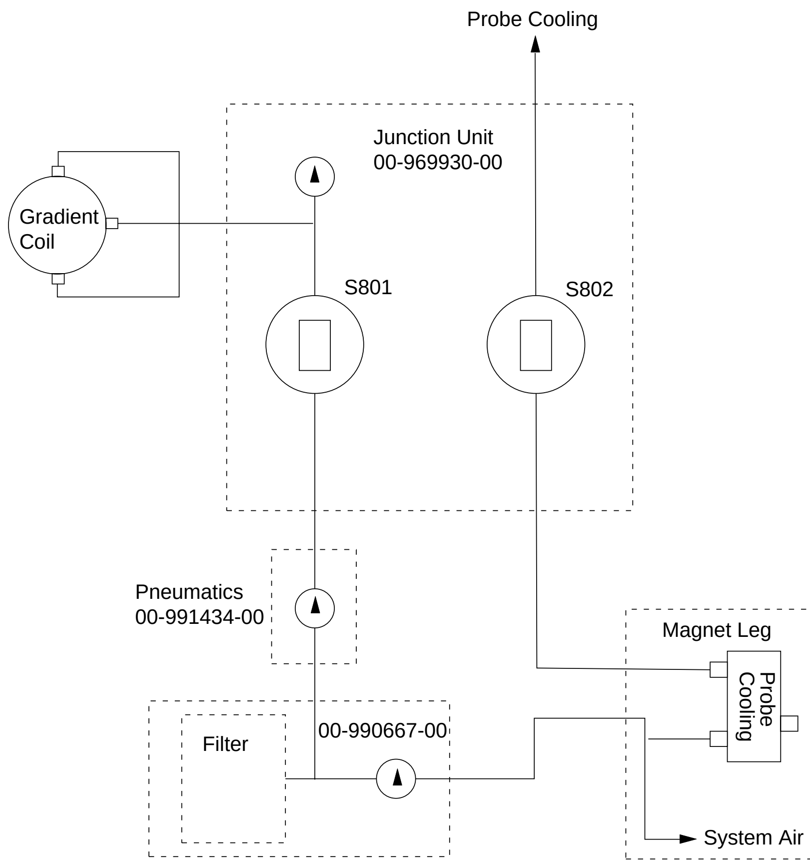

Figure 7. Air Flow Diagram

5. When the gradient coil is installed, connect it to both J806 (inside the junction unit) and to the 15-pin D shell J802 (mounted to the outside of the junction unit).

Installing the Air Cooling System

The gradient coil set and the microimaging probe use air for cooling. The air flow diagram in Figure 7 shows the required connections. Depending on the air flow requirements of the gradient coil, set the pressure sensor switch S801 and S802 accordingly.

Installing the Preamplifier Attenuator

This procedure describes how to install the preamplifier attenuator, which attenuates the output of the observe preamplifier before the signal reaches the single mixer.

1. Position the preamplifier attenuator (00-969935-00) on the floor near the magnet leg.
2. Disconnect cable 00-958298-08 from the observe preamplifier output J5312 and connect it to the preamplifier attenuator output.
3. Use cable 00-958298-03 to attach the preamplifier attenuator input to the observe preamplifier output J5312.

Installing Gradient Coils and the Microimaging Probe

Refer to the *NMR Probes Installation Manual* for the following procedures:

- Installing gradient coils
- Inserting a sample into the microimaging probe
- Installing and connecting the microimaging probe

Configuring VNMR for Microimaging

The microimaging software option can be installed at any time from the VNMR CD-ROM. Refer to the *VNMR and Solaris Software Installation Manual* for more information.

Run `config` to add gradients, using Table 3 as a guide. (WFG+SDAC refers to the waveform generator and the Smart DAC board.)

Table 3. Typical Microimaging Software Configuration File

Label	*Value*
RF Channel 1 (Obs):	
Type of RF:	U+ Direct Synthesis
Synthesizer:	PTS 500
Latching:	Present
Frequency Overrange:	100, 000
Frequency Step Size:	0.1 Hz
Coarse Attenuator:	79
Upper Limit:	63 dB
Fine Attenuator:	Present
Waveform Generator:	Present
Type of Amplifier:	Linear
Axial Gradients	
X Axis	WFG + SDAC
Y Axis	WFG + SDAC
Z Axis	WFG + SDAC

Testing and Verifying the Gradient System

The following gradient system items are tested:

- Gradient controls
- Gradient compensation system
- Gradient coil assignments

Testing Gradient Controls

This procedure describes how to test the direct-write and shaped-write gradient control paths. Perform gradient controls tests with the gradient amplifiers off or on standby. Gradients are controlled through waveform generators.

1. Test the direct-write control path as follows:

   a. Enter **`decctool`** and create a file.

   b. Enter **`rtp('/vnmr/parlib/gtest1')`** to recall the `gtest1` parameter set.

   c. Set **`orient='xnn'`** to select the X channel. Set **`gro=32767 d2=0.001 tpwr=0 pw=0 nt=1000`**.

   On the Smart DAC board's "X" test point, you should measure 5 V for 2 ms. Setting `gro=–32767` should result in a –5 V measurement, and `gro=0` should give a measurement of 0 V.

   d. Repeat steps a and b for the Y and Z gradients by changing **`orient='ynn'`** and then **`orient='znn'`**, respectively.

2. Test the shaped-writer control path as follows:

   a. Enter **`rtp('/vnmr/parlib/gsh2pul')`** to recall the `gsh2pul` parameter set.

   b. Set **`orient='xnn' gname='hsine' gro=32767 tpwr=0 pw=0 nt=1000`**.

   c. Set **`tro=0.0005`** (i.e., 500 μs). Entering **`go`** should produce a one-half sine wave at maximum of +5 V. The pattern should be smooth and continuous. Change `tro` to **`tro=0.0100`** (i.e., 10 ms) and enter **`go`**. The pattern should still look smooth and continuous.

   d. Repeat steps a, b, and c for the Y and Z gradients, using entering **`orient='ynn'`** for Y and **`orient='znn'`** for Z.

Testing the Gradient Compensation System

Each gradient compensation unit (X, Y, Z) requires the following functional tests:

1. Make sure the gradient amplifiers are either off or in standby
2. Enter the macro **`techron`**. This recalls the compensation file named `techron` for Techron amplifier setup and sends it to the gradient compensation units. Any SDAC duty cycle lights should be clear. The status panel is either clear or blinking until manually reset.
3. Enter **`gro=32767 d1=2 pw=0 tpwr=0 go`**. You should see the following results on an oscilloscope:
   - +5 V output at corresponding Gradient DAC output test point
   - no amplitudes associated with the time constants

- 2.5 V (50% of 5 V) output voltage at output test point on the corresponding SDAC O/P board because gain was set to 50%
- GCU duty cycle light blinking slowly (depending on thresholds)

For each gradient in turn, complete the following steps:

1. Enter **decctool** to open the decctool window.
2. With decctool, set files to **global** and select **techron** from the scrolling list.
3. Click the **setup** button.
4. Set files to **local**, select **temp**.
5. Set the overall gain to 40 and the duty cycle to 80 for each gradient. Click **save**.

   With **orient='xnn'** for X, **orient='ynn'** for Y, or **orient='znn'** for Z, you should see the following results from each gradient test point on the SDAC board:

   - 2 V (40% of 5 V)
   - no duty cycle lights
   - no amplitudes associated with the time constants
6. Use decctool to set all amplitudes to 100% and repeat steps 2 to 5 above for each gradient. A probe of all test points should show an exponential decay at the specified time constant.
7. Reset the files to **global**, select **techron**, and click the **setup** button.

Calibrating and Configuring Gradient Strength

Before the procedures in this section can be performed, the gradient coils must have been properly matched to the amplifiers and the 90 pulse width calibration of the rf probe must have been determined.

Creating the RF Pulse Calibration File

This procedure describes how to create the rf pulse calibration file.

- From previous results of the 90 pulse width, use the**pulsecal** command to create the rf pulse calibration file as follows:
  pulsecal('name of coil','pattern',length,flip-angle,power)
  For example, pulsecal('rfcoil1','hard',75,90,55).
  This entry is saved into a text file called pulsecal in the ~/vnmrsys directory.

Calibrating Gradient Strengths

This procedure describes how to calibrate the strength of the Techron gradient amplifiers.

1. Set the overall gain setting in the decctool window to the appropriate gradient coil maximum specifications (e.g., if the gradient coil has a maximum specification of 30 G/cm at 50 amps at 20% duty cycle, set the overall gain to 50 and duty cycle to 20 (or 15 to be on the safe side).
2. Click **save** in the deccTool window.
3. Place the cube-in-cube phantom into the coil approximately at the center of Z axis.

4. Enter **`profile`** to load the profile parameter set.
5. If the `gradaxis` parameter does not exist, create it:
   `create('gradaxis','string') gradaxis='z'`
6. Enter **`gzlvl1=8000,-8000 d1=1 d2=0.02`**. Set **`p1`** to the 90° pulse, **`pw`** to the 180° pulse, and **`tpwr`** to the appropriate level.
7. Enter **`ga`** and then **`dssa`** to obtain the two profiles.

   You might need to set the attenuator box to 20 dB or 30 dB to avoid ADC overflow.
8. Adjust the length of the positioner until the two profiles coincide, which centers the sample in the Z axis.
9. Display one of the profiles (e.g., **`ds(1)`**) and measure the width of the profile (in Hz) at 25% height at each end.
10. Enter **`setgcal`** and answer the following questions.

    `What is the size of the object (cm)?` **1.2**

    `What is the frequency spread (Hz)?` **45500**

    `What is the gradient value (dac#s)` **8000**

    Answer **`y`** to the value of `gcal` calculated by the `setgcal` macro. If the maximum gradient strength calculated is less than the specified value of the gradient coil, change the gain setting for the Z gradient in decctool and repeat steps 8 through 11 until the value is reached. Write down the value of the maximum gradient strength which will be used in creating the gradient table.

Creating the Gradient Table

1. Enter **`creategtable`** and the following information:

   Are all gradient axes calibrated to the same maximum value? y/n: **`y`**

   Enter (m) for main coil, (h) for HPAG coil, (o) for other: **`o`**

   Enter a name for gradient coil entry: **`gcoil1`**

   Enter a brief description of this gradient table: **`Large imaging coil`**

   Enter the boresize in (cm): **`10`**

   Enter the maximum gradient strength (gauss/cm): **`30`**

   Enter the risetime (µsec): **`100`**

   The maximum gradient strength is the value from the specification.
2. Join another experiment and enter **`sems`** to load the `sems` parameter set.
3. Set the `rfcoil` to the **`pulsecal`** file name and set the `gcoil` to the name of the gradient calibration coil that was set in step 1 (e.g., `rfcoil='imaging-coil' gcoil='gcoil1'`)
4. Set the following parameters:

`thk=1`	Slice of thickness in 1 mm
`lro=3 lpe=3`	Field of view, readout, and phase encode to 3 cm
`p1=2000 p2=2000`	2-ms pulse width
`p1pat='gauss'` **`p2pat='gauss'`**	Use Gaussian selective pulses

5. Enter **`imprep`** to set up the imaging pulse sequence.

6. Enter **orient='sag' nv=0 gro=gro,-gro d1=2 nt=1 ga** to obtain readout profiles along Z direction. Adjust the position of the sample up or down so that the two profiles coincide, which centers the sample in the Z coil.
7. Enter **orient='trans' nv=64 tr=1 go** to obtain an image. Transform the image with **ft2d** and rotate the sample positioner so that the image appears level. Enter **go** to obtain another image.
8. Enter **orient='sag' nv=128 ft2d** to obtain an image and transform the data.
9. Set the two cursors at the edge of the square image in the F2 dimension. Write down the value of delta in Hz.
10. Calculate the value of `gro` in DAC units as follows:

    `gro` (DACs) = `gro` (G/cm) / `gmax` (G/cm) * 32767
11. Enter **setgcal** to recalibrate `gcal` using the value of `gro` in DACs calculated above. Note that the macro `setgcal` calculates `gmax` in G/cm.
12. Enter **creategtable**, which updates the gradient table file created in step 1 with the new `gmax` value calculated in the previous step.
13. Set **gcoil** and **sysgcoil** to the gradient coil name and enter **imprep** to reset `gro`, `gpe`, and other parameters in the `sems` experiment.
14. Obtain the image again and check the dimension of the cube image. Repeat steps 8 through 13 until the dimension of the cube image is exactly 1.2 cm.

Calibrating Gradient Strengths (ecctool)

1. Set the gain setting in the ecctool to the appropriate gradient coil maximum specifications. For example, if the gradient coil has a maximum specification of 30 G/cm at 50 amps at 20% duty cycle, set the gain to 50 and the duty cycle to 20 (or 15 to be on the safe side).
2. Create a file in the local directory (`~/vnmrsys/imaging/eddylib`), such as `main`, with the X, Y, and Z gradients set to a gain of 50 and duty cycle of 15.
3. Select **setup** in the ecctool window and execute a setup.
4. Place the cube-in-cube phantom into the coil approximately at the center of the Z axis.
5. Enter **profile** to load the profile parameter set.
6. If the parameter gradaxis is not present, create it:
   create('gradaxis','string') gradaxis='z'
7. Enter **gzlvl1=8000,-8000**. Set **p1** to the 90° pulse and **pw** to the 180° pulse. Set **d1=1**, **d2=.02**, and **tpwr** to the appropriate level.
8. Enter **ga** and then **dssa** to obtain the two profiles.

   You might need to set the attenuator box to 20 dB or 30 dB to avoid ADC overflow.
9. Adjust the length of the positioner until the two profiles coincide, which centers the sample in the Z. axis.

Creating the RF Pulse Calibration File

From the previous results of the 90° pulse width, create the RF pulse calibration file with the following command:

pulsecal('name_of_coil','pattern',length,flip-angle,power)

For example, `pulsecal('rfcoil1','hard',75,90,55)`

This entry is saved into a text file called `pulsecal` in the `~/vnmrsys` directory.

Creating the Gradient Table

1. Enter **createtable** and the following information:

   Are all gradient axes calibrated to the same maximum value? y/n: **y**

   Enter (m) for main coil, (h) for HPAG coil, (o) for other: **o**

   Enter a name for gradient coil entry: **gcoil1**

   Enter a brief description of this gradient table: **Large imaging coil**

   Enter the boresize in (cm): **10**

   Enter the maximum gradient strength (gauss/cm): **30**

   Enter the risetime (μsec): **100**

   The maximum gradient strength is the value from the specification.

2. Join another experiment and enter **sems** to load the `sems` parameter set.
3. Set the `rfcoil` parameter to the **pulsecal** file name and the `gcoil` parameter to the name of the gradient calibration coil that was set in step 1 (e.g., `rfcoil='imaging-coil' gcoil='gcoil1'`).
4. Set the following parameters:

thk=1	Slice of thickness in 1 mm
lro=3 lpe=3	Field of view, readout, and phase encode to 3 cm
p1=2000 p2=2000	2-ms pulse width
p1pat='gauss' **p2pat='gauss'**	Use Gaussian selective pulses

5. Enter **imprep** to set up the imaging sequence.
6. Enter **orient='sag' nv=1 gro=gro,-gro, d1=2 nt=1** and type **ga** to obtain readout profiles along the Z direction. Adjust the position of the sample up or down so that the two profiles coincide, which centers the sample in the Z coil.
7. Enter **orient='trans' nv=64 tr=1** and type **go** to obtain an image. Transform the image with **ft2d** and rotate the sample positioner so that the image appears level.
8. Enter **orient='sag' nv=128** to obtain an image. Enter **ft2d** to transform the data. Set the two cursors at the edge of the square image in the F2 dimension. Write down the value of delta in cm.
9. Calculate the value of `gain` for the Z gradient in ecctool as follows:

   Z gain (new gain setting)=`gain`(current setting in ecctool)*_factor_

   where *factor* is the ratio of the displayed size and the actual size of the cube.

   Set the two cursors at the edge of the square image in the F1 dimension. Write down the value of `delta1` in cm. Calculate the value of gain for the X gradient.

   Y gain (new gain setting)=`gain`(current setting in ecctool)*_factor_

   where *factor* is the ratio of the displayed size and the actual size of the cube.

10. In ecctool, save the new setting and load the file to the GCU and repeat step 8 until the displayed size in both dimensions is exactly 1.2 cm.
11. Repeat steps 8 and 9 with `orient='cor'` and adjust the gain setting for X using F1 dimensions.

System Protection and Status

The gradient system safety interlock board is located on the top side of the cabinet. The safety interlock board interprets diagnostic information provided by the amplifiers and coil system (via the junction unit) and determines whether the gradient amplifiers should be enabled or disabled. The safety interlock board also drives the shim switch unit and the gradient cabinet status panel (see Figure 8).

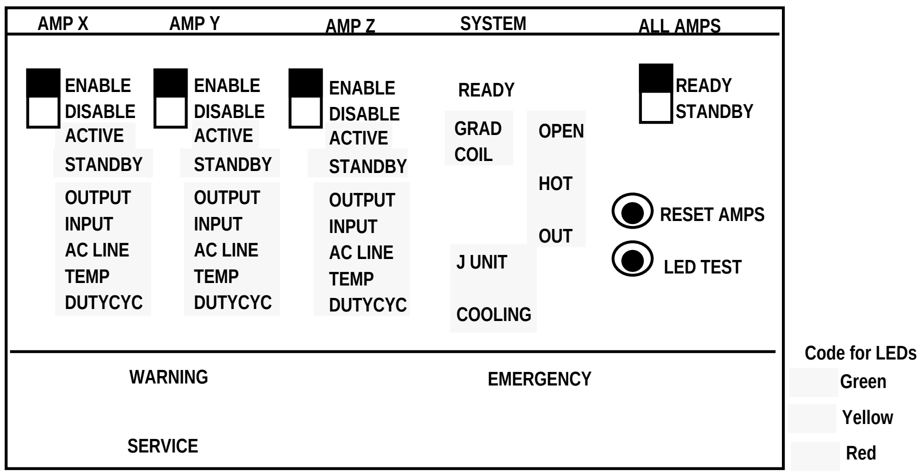

Figure 8. Gradient Interlocks and Status Display

The purpose of the gradient interlock and status display is to prevent serious damage that could be caused by the high currents produced by the gradient amplifiers. Additional protection and status is built into the gradient amplifiers (see Figure 9). and the fuse block in the junction unit (see Figure 10).

WARNING: **Do not disable the gradient interlock. The gradient amplifiers produce high currents that could result in serious injury or death.**

Table 4 lists amplifier faults and Table 5 lists gradients system faults. The information in these tables should help the operator determine the cause of a fault indication.

A steady, nonblinking red light on any of the faults indicates that the fault is currently active and needs correcting. A flashing red light indicates that the fault occurred previously but no longer exists.

The normal mode for turning on the power to the gradient amplifiers is as follows:

1. Set the **READY/STANDBY** switch on the front of each gradient amplifier to READY.
2. Set the **ENABLE/DISABLE** switch on the status display panel to **DISABLE** for each amplifier (the yellow STANDBY LED will go on).
3. Power on each amplifier with its circuit breaker (rear of amplifier chassis).

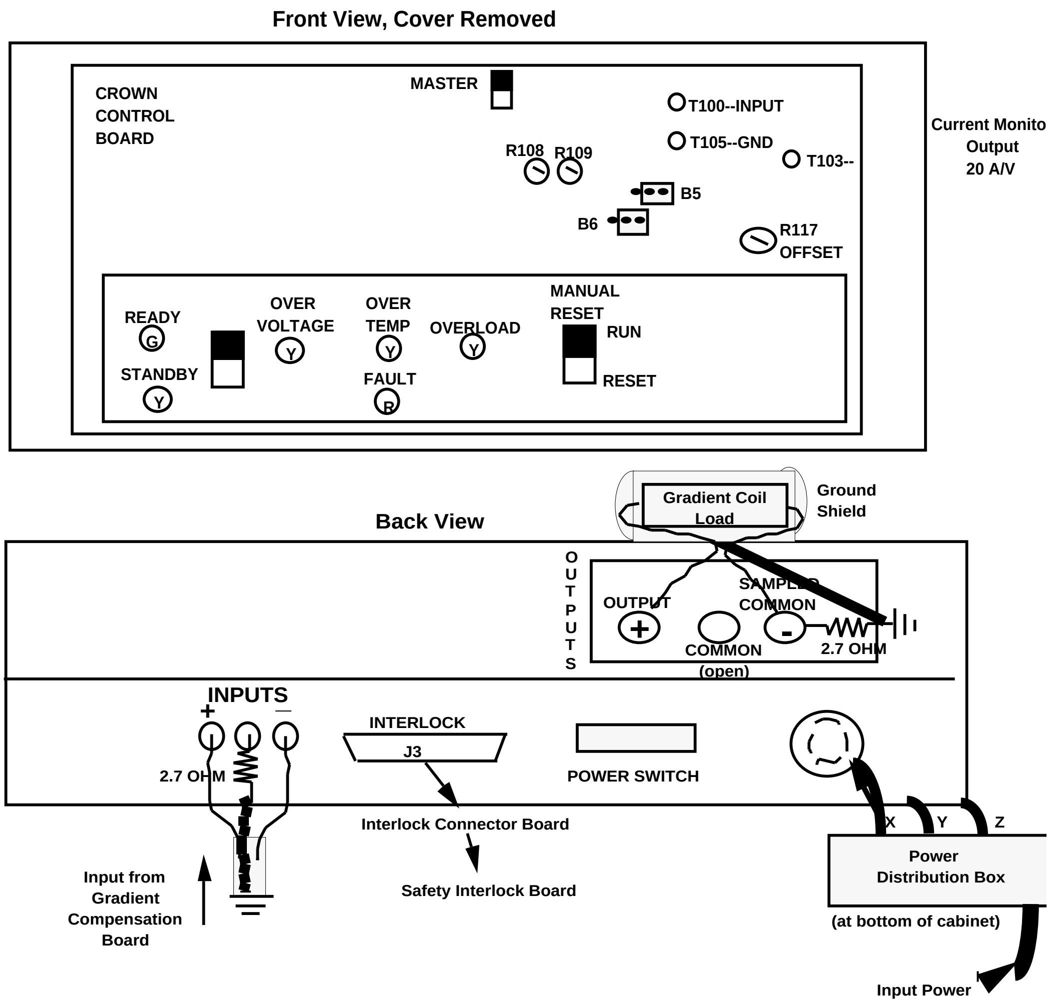

Figure 9. Gradient Amplifier, Front View (top), Back View (bottom)

Table 4. Amplifier Faults

Display	*Meaning*
`OUTPUT`	Voltage to gradient coil is too high; occurs when load is open.
`INPUT`	Input from GCU is too high and gives too much power to the coil.
`AC LINE`	Input line voltage is too high by 10% or more.
`TEMP`	Output transistors or amplifiers are too hot.
`DUTYCYC`	Input from GCU is too high and gives too much power to the coil. The duty cycle threshold value is set by the user from the ecctool window.

4. Press the **RESET** button on the status panel. If no faults occur, the READY LED and all three ACTIVE indicators will light.

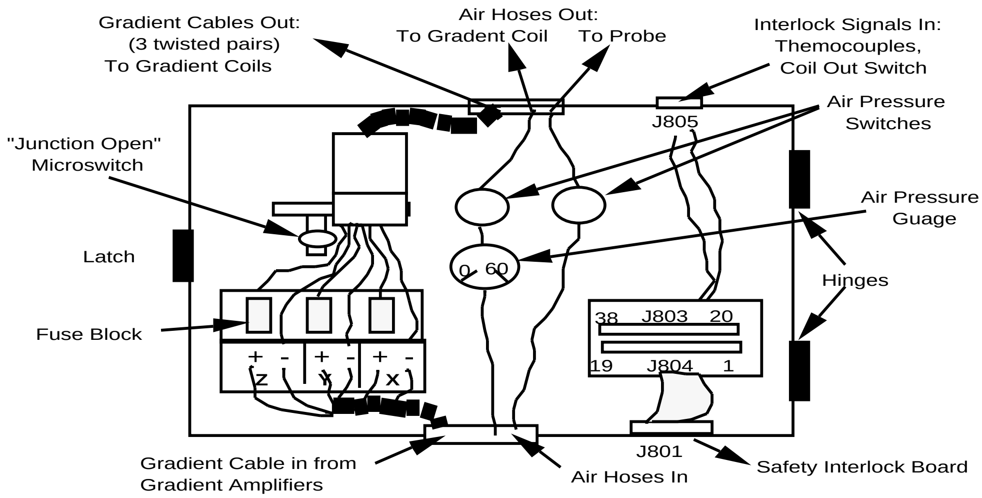

Figure 10. Gradient Junction Unit, Top View

Table 5. Gradient System Faults

Display	*Meaning*
`COIL OPEN`	Load is open (coils, cables, or fuses).
`COIL HOT`	Thermocouples inside the coil measure a temperature over 75°C.
`COIL OUT`	Gradient coil set is removed from the magnet bore.
`J UNIT`	Interlock in the Gradient Junction Unit is not made (cover open).
`COOLING`	Pressure switches on Gradient Junction Unit indicate cooling air to gradient coils is not present.

Other operational considerations include:

- If the slide switch on the gradient amplifier is set to **STANDBY**, the status panel will also read STANDBY.
- Any fault will cause all enabled amplifiers to go into STANDBY.
- Press the **LED TEST** button to check that all indicator lights are functional.
- If the DUTY CYCLE indicators are on, do a setup from the decctool window to clear them.
- If any of the cables leading to J5 on the interlock board are not connected properly, all the system fault lights will be on solid.

When powering up the gradient system, the indicator lights may go into “blinking” mode. You can remove this condition by pressing the **RESET AMPS** button on the status panel.

Index

R

S

T

U

V

W